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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Apparatus for Embossing and Laminating Materials.

We, MARC ALFRED CHAVANNES and ALFRED WILLIAM FIELDING, Citizens of Switzerland and of the United States of America respectively, of 57 Montague Street, Brookyln 1, New York, and 907 Pine Lake Drive West, Wayne, New Jersey, both of the United States of America, respectively, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the embossing and laminating of materials and more specifically to an improved apparatus for embossing synthetic plastics and for laminating such embossed materials with other sheet synthetic plastic materials.

The apparatus in accordance with the invention, while being generally useful, is particularly applicable for use in the fabrication of cushioning material wherein air is entrapped between laminated layers of synthetic plastic sheets. To this end, the invention contemplates an improved apparatus for handling the plastic materials being formed and laminated that enables the attainment of high operational speeds and at the same time prevents distortion of the plastic sheets prior to and during the forming operation.

Another object of the invention resides in the provision of an improved apparatus which greatly facilitates embossing and laminating of synthetic plastic materials that is characterised by its relatively high operational speeds, dependability and reliability.

Another object of the invention resides in the provision of an improved embossing roller arranged to cool selected portions of an embossed film while the film is retained under a vacuum to hold its form during the cooling operation. By reason of an improed arrangement and co-ordination of elements, the improved roller not only facilitates the lamination of the selectively cooled and embossed film with other plastic sheets to seal the embossed portions, but also simplifies the roller construction and facilitates modification of the embossing surface on the roller.

Still another object of the invention resides in the provision of an impoved embossing roller for embossing plastic materials.

A further object of the invention resides in an improved pressure and vacuum system for embossing plastic materials. With these objects in view, the present invention provides apparatus for embossing and laminating synthetic plastic films or sheet materials comprising an embossing roller including a cylindrical shell mounted for rotation and containing a chamber through which cooling fluid may be circulated, vacuum passages being provided in communication with surface openings or pockets of the roller to permit vacuum to the applied to such openings or pockets, said passages being connected to a vacuum conduit, means for heating a first synthetic plastic film or sheet to embossing temperature and feeding it continuously to the embossing roller, means for heating a second synthetic plastic film or sheet to a fusing temperature and feeding it onto the embossing roller in overlying relationship to the first film or layer, and a take off roller for receiving the combined films as they pass off the embossing roller after having cooled thereon.

The invention will be described further, by way of example, with reference to the accompanying drawings, most of the figures

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of which are common to our co-pending Patent Application No. 22717/63 (Serial No. 942,215) which concerns a "Method for embossing and laminating articles". In the accompanying drawings:—

Fig. 1 is a diagrammatic view of one embodiment of laminating and embossing apparatus in accordance with the invention;

Fig. 2 is a diagrammatic view of a modified embodiment of the laminating and embossing apparatus of the invention;

Fig. 3 is a diagrammatic view of still another embodiment of apparatus according to the invention, wherein at least three synthetic plastic sheets or films are laminated to produce a cushioning material;

Fig. 4 is a diagrammatic view of still another embodiment of the apparatus of the invention, showing improved film handling means;

Fig. 5 is a diagrammatic view of still another embodiment of the apparatus, utilizing pressure and vacuum embossing;

Fig. 6 is an enlarged part-section view showing a part of Fig. 5 to illustrate certain characteristics thereof;

Fig. 7 illustrates in diagrammatic form still another embodiment of the apparatus according to the invention which provides improved film support during the embossing and laminating operations;

Fig. 8 is a cross sectional view of an embossed and laminated material fabricated in accordance with the invention;

Fig. 9 is a cross sectional view of an embossed and laminated material of the type such as may be produced by the apparatus shown in Fig. 3;

Fig. 10 is a cross sectional view of an improved embossing roller in accordance with the invention, the section corresponding to the line 10—10 of Fig. 11;

Fig. 11 is a cross sectional view taken along the line 11—11 of Fig. 10;

Fig. 12 is a cross sectional view taken along the line 12—12 of Fig. 11;

Fig. 13 is a cross sectional view taken along the line 13—13 of Fig. 12;

Fig. 14 is a view taken in the direction of the arrow 14 of Fig. 12;

Fig. 15 is a cross sectional view, similar to Fig. 12, of the roller shown in Figs. 9, 10 and 11, but shows a modified arrangement for extracting air from the embossing recesses formed in the surface of the roller to effect the embossing process;

Fig. 16 is a cross sectional view taken along the lines 16—16 of Fig. 15;

Fig. 17 is a fragmentary portion of Fig. 12, but illustrates a modified mode of extracting air from the embossing recesses to effect the embossing process; and

Fig. 18 is a fragmentary view corresponding to Fig. 12 but illustrates still another

Referring now to the drawings and more specifically to Fig. 1, there is diagrammatically illustrated one form of the invention which is useful, among other things, for the fabrication of a product such as that illustrated in Fig. 8. It will be observed with reference to Fig. 8 that the product (denoted generally by the numeral 10) comprises an embossed or moulded synthetic plastic layer or film 11, having a plurality of closely spaced embossments 12 distributed throughout the area of the film 11, and a sealing layer 13 hermetically sealing the embossments 12 to provide a plurality of cells 14 distributed over the surface of the material.

The structure shown in Fig. 1 utilizes an improved embossing roller 15 in accordance with the invention. Various embodiments of suitable embossing rollers are shown in detail in Figs. 10 to 18 of the drawings and will be described in connection with those figures. The two layers or films of synthetic plastic material 11 and 13 may be of any desired thickness, although films in the range of .001" to .025" are generally used. The actual thickness of the films selected for a specific product would, of course, be determined by the characteristics required of the resultant material 10.

More specifically, the synthetic plastic layer or film 11 may be fed from a supply roller 16 or other supply source to a first roller 17 which preferably includes a rubber or rubber-like surface. The film 11, after passing about the first roller 17 engages a pair of heating rollers 18 and 19. The heating rollers 18 and 19 are disposed, relative to the first roller 17, so that the film 11 will contact substantial parts of their peripheries and thereby provide the maximum time for imparting heat to the film 11. Inasmuch as it has been found desirable to heat the film 11 gradually, the heating roller 19 is maintained at a temperature above that of the heating roller 18. The film 11 then passes about an idler roller 20, an expanding roller 21 and heating rollers 22 and 23. The expanding roller 21 is made up of a plurality of longitudinal elements disposed in side-by-side relationship to form a cylindrical structure. These longitudinal elements are arranged to be displaced radially outwards during rotation of the expanding roller 21. Such radially outward movement occurs only as each successive longitudinal element contacts the film 11, and the elements are thereafter retracted so that when they again contact the film 11 they will be moving laterally to effect expansion of the film 11. The heating roller 22 further heats the film 11 and the final heating roller 23 is customarily at a temperature close to or above the melting point of the film 11 so that the film 11 is heated to the necessary level of tempera-

is fed to the embossing roller 15. As will be described, the embossing roller 15 is vacuum operated and is provided with a plurality of cells formed in the surface thereof for the purpose of forming the embossments 12 and cells 14 (see Fig. 8) in the final article. The embossing roller 15 is also water-cooled in a manner that will effect cooling of the moulded portions of the film 11 and may be arranged to prevent cooling of unmoulded portions of the film 11 for the purpose of sealing the second or sealing plastic layer 13 thereto.

By way of an example of the temperatures of the heating rollers 18, 19, 22 and 23 referred to above, when utilizing a low density polyethylene having a thickness of about .005" and a melting point of approximately 235° F., the heating roller 18 may be heated to about 180° F., the heating roller 19 may be heated to about 200° F., the heating roller 22 may be heated to about 225° F. and the heating roller 23 may be heated to about 260° F. The film 11 is caused to travel over such rollers at relatively high speed, so that the temperature of such film is brought in the vicinity of its melting point, although it is important that melting of the film 11 is not actually reached.

The second or sealing layer 13 is fed from a suitable film source such as a roll 24, thence about a rubber surfaced roller 25, heating rollers 26 and 27, an idler roller 28, an expanding roller 29 and heating rollers 30 and 31. The rollers 26, 27 and 30 and 31 are heated to successively increasing temperatures so that the roller 31 will cause the sealing layer or film 13 to attain a temperature in the vicinity of its melting point. The heating roller 31 is also in pressure engagement with the embossing roller 15 so that as the sealing layer or film 13 is applied to the embossed film 11, the two films will fuse one to the other so as permanently to seal the embossments 12 and thus provide the sealed cells 14, as previously described. The sealing of the films 11 and 13 one to the other occurs only at the unembossed areas 11' of the film 11, as may be observed more clearly in Fig. 8. It will also be observed that the sealing layer or film 13 is applied to the film 11 in close proximity to the point of application of the film 11 to the embossing roller 15 to minimise cooling of the salient portions of the film 11 to which the sealing film 13 is fused. If desired, heating means may be introduced between the heating rollers 23 and 31 to ensure maintenance of the unembossed areas 11' of the film 11 at the fusing temperature. After the fusion has been completed the combined films continue about the embossing roller 15 so that the product will be properly cooled before removal by a take off roller 32 and suitable transporting means such as a conveyor which includes conveyor rollers 33 and 34 and a co-operating belt 35.

Under certain conditions it is desirable to provide for more rapid cooling of the combined film after lamination and thereby permit greatly increased speeds of operation. This can be attained by the embodiment of the invention shown in Fig. 2 which constitutes a fragmentary portion of Fig. 1 and in which corresponding elements of both figures are denoted by like reference numerals. In Fig. 2 a shield 36 is disposed beneath the heating roller 31 and in close proximity to the embossing roller 15. Water injection means 37 is disposed beneath the shield 36 and sprays a cooling stream of water or other coolant directly upon the surface of the laminated films 11 and 13. Thie effects rapid cooling and sealing of the films and prevents any possibility of separation of the films during their travel about the embossing roller 15. When liquid coolants are employed, a suitable trough 38 is disposed beneath the embossing roller 15 to receive the sprayed liquid, whereupon it may be circulated through suitable cooling apparatus and associated pumps back to the water injection means 37. When utilizing a coolant, the degree of cooling may be controlled by varying the temperature of the coolant, as well as the point on the embossing roller 15 at which the coolant is applied. When the laminated film is cooled by a liquid coolant it is dried by use of pressure jets 39 and 40 from which dry air or other suitable gas is discharged against the laminated film under pressure. In this way, the jets 39 and 40 operate in the manner of doctor blades to remove or evaporate the liquid coolant from the surface of the film and effect complete drying of the laminated film before the latter is removed by the take off roller 32, as described in connection with Fig. 1.

While the films 11 and 13, which are embossed and laminated as described in connection with Figs. 1 and 2 may be of any suitable material, it is, of course, important that the films should be of a material that will soften and melt with an increase in temperature. While films of this type are generally referred to as "thermoplastic", and such films are generally utilized with this invention, nevertheless, it is not intended that this invention is to be limited to the use of films classified generally in the trade as "thermoplastic" films, as any film capable of being moulded and sealed by apparatus in accordance with the invention may be used. For example, a film of an unset thermosetting resin which undergoes a thermoplastic phase during heat thereof, may be employed.

The apparatus illustrated in Fig. 3 serves for the production of the laminated article shown

in cross section in Fig. 9. This article corresponds to the article shown in Fig. 8, and corresponding elements of these figures are denoted by like numerals, except that the article of Fig. 9 is generally denoted by the numeral 10'. It will be observed, however, that the article shown in Fig. 9 includes an overlying synthetic plastic layer or film 42 which is heat-sealed to the upper surfaces 12' of the embossments 12. The heat sealing of the layer 42 to the embossments 12 may be effectively and reliably accomplished by the structure generally shown in Fig. 3. In this figure that portion of the apparatus utilized for the handling and heating of the film 11 and the sealing layer 13 and the embossing and laminating of these films is substantially identical to the structure shown in Fig. 1, and accordingly corresponding elements are denoted by like numerals. When the two films or layers 11 and 13 have been embossed and laminated as previously described, the resultant product which now corresponds essentially to that shown in Fig. 8 is removed from the embossing roller 15 by a pair of take off rollers 43 and 44 carrying a surrounding take off belt 45. This belt 45 may be of any suitable material, as for instance, stainless steel, fabric or the like, and should be sufficiently taut to support the laminated film firmly. This laminated film, upon leaving the embossing roller 15 for transport about the take off roller 43 by the belt 45, has now been cooled and each of the individual cells 14 hermetically sealed preparatory to the application of the overlying film 42.

The overlying film 42 may be obtained from any suitable source of supply as, for instance, a roll 46 of the film and it is fed about a series of feed rollers 47 to 53. The feed rollers 48 and 49 are heating rollers for successively increasing the temperature of the overlying film 42. The film 42 then passes over an idling roller 50, and an expanding roller 51, the latter corresponding to the expanding rollers 21 and 29 previously described. The film 52 is then carried over heating rollers 52 and 53 to raise the temperature of the overlying film 42 to a fusing temperature. The heating roller 53 is in pressure engagement with the laminated structure on the take off belt 45 and leaving the embossing and laminating roller 15 and functions to urge the heated overlying film 42 tightly against the embossments 12 of the sealed cells 14.

It will be observed at this point of the process that, while the hermetically sealed cells 14 have been cooled, a heat seal can be effectively attained, since it has been found that sufficient heat will be transferred from the overlying film 42 to the embossments 12 of the cells 14 which are contacted by the overlying film 42 and will thereby effect a joining of the meeting surfaces. This apparently results from the fact that the synthetic plastic film utilized in the formation of the cells 14 is a relatively poor heat conductor so that when the overlying film 42, which has a temperature at about its melting point, is applied a firm joint will result. Furthermore, inasmuch as the cells 14 are hermetically sealed, substantial pressure can be applied to uge the overlying film 42 into contact with the cell embossments 12 without damaging them in any way.

After the overlying film 42 is joined to and overlies the cells 14, the resultant triple laminate (denoted by the numeral 10' in Fig. 9) then passes beneath a cooling belt 54 of stainless steel or other suitable material. This cooling belt 54 is carried by five rollers 55 to 59, the rollers 56 to 59 being relatively small rollers, and the roller 55 being a relatively large cooling roller over which the cooling belt 54 travels throughout a substantial portion of its periphery. The cooling belt rollers 56 and 59 are spaced a distance apart and are in pressure engagement, through the cooling belt 54, with the resultant product 10' to hold the overlying film 42 in tight engagement with the cell embossments 12 until its temperature has been lowered sufficiently to ensure permanent joining. The completed product 10' is then transported from the apparatus by a suitable conveyor such as the conveyor belt 60 carried by conveyor rollers 61 and 62.

In the embodiments of the invention so far described, the heated films are fed to the moulding and laminating roller 15 by means of heated rollers. While rollers provide an effective means for heating and applying the film to the embossing roller 15, in certain cases it is desirable to feed at least one of the films tangentially onto the embossing roller 15 and to avoid actual contact of the heated film with roller surfaces. This may be attained by an improved film heating and transporting means of the form illustrated in Fig. 4 of the drawings. In this figure, the film 11 to be embossed may be heated by means of rollers in substantially the same manner as illustrated and described in connection with Fig. 1. After the film 11 has been preheated by heating rollers such as the rollers 18, 19 and possibly also the heating roller 22 of Fig. 1, the film 11 enters the area between a pair of manifolds 63 and 64. These manifolds 63, 64 extend throughout the entire axial length of the embossing roller 15 which is substantially identical to the embossing roller 15 of Fig. 1, and are each provided with a plurality of orifices 63' and 64'. The manifolds 63, 64 are in spaced relationship and include inlets 65 and 66 for the admission of gas, such as air or the like, under pressure. As it is desirable to supply additional heat to the film 11 in

order to raise its temperature to the proper embossing temperature as previously described, it is preferable to supply heated air to these manifolds 63, 64. The pressure on the two manifolds 63, 64 is controlled so that the film 11 will be supported solely by the gas emanating from the orifices 63' and 64' and will be guided onto the embossing roller 15. The utilization of manifolds has the advantage that these can be contoured so that they can be placed in close proximity to the embossing roller 15. In the present form of the invention, the upper manifold 63 may also extend beyond the point of tangency with the embossing roller 15 as indicated in dotted lines and thus continuously apply heat to the film even after contact with the embossing roller 15 and initiation of the embossing process. The second film or sealing layer 13 is handled by the expanding roller 29 and heating rollers 30, and 31 which correspond to the rollers which bear the same numerals in Fig. 1. After the embossing and laminating processes have been completed, the composite material is cooled and is removed from the embossing and laminating roller 15 by a take off roller 32 and the resultant product 10 is then conveyed from the fabricating apparatus.

Figs. 5 and 6 illustrate a modified apparatus for embossing and laminating film in accordance with the invention. In this embodiment, the film 11 to be embossed is preheated by means such as those described in connection with Figs. 1, 3 and 4 and is then fed on to a modified form of embossing roller 15. At the point of contact of the film 11 with the embossing roller 15, the film 11 is forced into depressions 67 on the embossing roller 15 (as may be observed in Fig. 6) by a pressure roller 68. The pressure roller 68 has a rigid core 69 covered by a resilient surfacing 70 of rubber or the like which functions to force the film 11 mechanimally into the depressions 67 on the embossing roller 15. At the same time, the depressions 67 are provided with suitable vacuum openings 71 which, in turn, are connected with a vacuum chamber 72 within the embossing roller 15. Thus, the film 11 is mechanically forced into the depressions 67 and then is retained in the depressions 67 by vacuum.

After the embossing operation has been accomplished, the second preheated film or sealing layer 13 is then applied by means of a pressure roller 73 which corresponds to the heating roller 31 of Fig. 1. The film or sealing layer 13 seals the embossments 12 of the film 11 to form a plurality of individual cells 14, as illustrated and described in connection with Fig. 8 and the completed and cooled product is removed by a stripping roller 74. The finished product is denoted in these figures by the numeral 75.

Fig. 7 illustrates a modified arrangement of elements for the feeding of synthetic plastic films 11 and 13 to be embossed and laminated on to the embossing roller 15 and then cooling the laminated structure rapidly in order to facilitate the attainment of higher speeds of operation. The product produced in accordance with this embodiment of the invention is denoted by the numeral 10 and corresponds to the structure generally shown in Fig. 8 of the drawings. It is to be understood, however, that while the cells 14 of Fig. 8 have a generally rectangular configuration, it is evident that they may be of any desired shape, for instance, hexagonal, or circular in cross-section, or hemispherical.

The film 11 to be embossed by the embossing roller 15 is preheated by a series of rollers in substantially the same manner as described in connection with Fig. 1. The preheated film 11 is then fed onto the embossing roller 15 by means of a heated roller 76 which raises the film temperature to a point near its melting point as may be required for proper embossing of the film. The second film or sealing layer 13 is also preheated in the manner illustrated and described in connection with Fig. 1 and is fed in pressure contact with the film 11 to provide a permanently fused laminate.

In this embodiment of the invention, the two films 11 and 13 are held in pressure engagement one with the other during the travel about the embossing roller 15 by meeans of an endless belt 77 which may be formed of a silicone-coated fabric, silicone film, tetrafluoroethylene film, or other suitable material. The belt 77 is fed about a series of belt rollers 78, 79, 80 and 81 which are heated in order to impart a relatively high temperature to the belt 77 just prior to the point at which it is fed onto the embossing roller. The film 13, as will be observed, is carried by the belt 11 during a portion of its movement about the roller 81 and is moved into pressure contact with the embossed film 11. Thereafter, the two films 11, 13 are held in pressure engagement by that portion of the belt 77 disposed about the embossing roller 15. The belt 77 is guided away from the embossing roller 15 by means of a take off roller 82 which also serves to strip the resultant product or material 10 from the embossing roller 15, the material 10 then being transported from the apparatus by suitable conveying means such as a conveyor roller 83. After leaving the embossing roller 15, the endless belt 77 is carried by a series of supporting rollers 84, 85, 86 and 87 which return it to the heating roller 78. In order to ensure constant pressure engagement of belt 77 with the roller 15 one or more of the supporting rollers are spring loaded and at least one other of such rollers is driven in order to move the belt 77 in synchronism with

the movement of the embossing roller 15.

Because the belt 77 is heated, the film 13 will have a constant supply of heat during the time it makes initial contact with the film 11 and for a short distance thereafter, to ensure complete fusion with the film 11.

In order to cool the resultant product 10 before removal from the embossing roller 15, cooling means are provided in the form of an endless cooling belt 88, of stainless steel or other suitable material carried by cooling belt rollers 89, 90 and 91. The cooling belt rollers 89, 90 and 91 are maintained at a relatively low temperature, preferably about or below room temperature, for the purpose of constantly cooling the cooling belt 88. When the cooling belt 88 moves into pressure contact with the outer surface of the endless belt 77, heat is withdrawn from the belt 77 and consequently the laminated product 10 thereon, so that by the time the resultant laminated product 10 is stripped from the embossing roller 15, its temperature has been substantially lowered and permanent fusion of the films is assured.

Under certain conditions it may be desirable to preheat the surface of the embossing roller 15 just prior to the application of the film 11 for the embossing operation. For this purpose, a suitable preheating plate 92 may be provided and placed in close proximity to the surface of the embossing roller 15 in advance of the heated roller 76. Preheating of the embossing roller 15 may, of course, be utilized with the embodiments of the invention previously described.

A preferred form of the embossing roller 15 is shown in Figs. 10 to 14. This roller 15 may be made in any desired length and affords a number of advantages, including independent control of the vacuum embossinfi means and cooling means, as well as automatic valving for the control of the vacuum to avoid unnecessary loss of vacuum over exposed portions of the embossing roller 15 between the point of application of the film to be embossed and the point at which the final product is stripped from the roller 15.

More specifically, the embossing roller 15 includes a central hollow shaft 100 having threaded inserts 101 secured in the ends thereof for the reception of conduits 102 for the introduction and removal of a cooling liquid such as water or the like. The shaft 100 is rotatably mounted by suitable bearings 103 and may be driven in any desired manner as, for instance, by means of a suitable pulley or gear secured to the shaft 100 for the transmission of power to the roller structure.

The roller in accordance with the invention is fabricated of a number of independent elements secured one to the other in order to reduce fabrication costs and provide an improved and more dependable structure. More specifically, the roller includes a pair of circular elements or hubs generally denoted by the numerals 104 and 105, and of identical construction. Each of these hubs includes a central portion 106 and an outwardly extending flange 107 of appreciable thickness. The flange 107 is set back from the inner edge 108 of its hub 104 or 105 to form a cylindrical surface portion 109 and the outer portion of the hub 104, 105 is of reduced thickness to form adjoining bearing surfaces 110 and 111. The flanges 107 each include a plurality of radially disposed passages 112 through which air is exhausted and which terminate at their lower ends in axially disposed openings 113 which, in turn, terminate in the face 111 of the hub. The outer ends of the radially disposed passages 112, the relative angular positions of which may be observed more clearly in Fig. 11, are closed by suitable plugs 114.

The two hubs 104 and 105 are carried near the ends of the shaft 100 and are each provided with recesses 115 for the reception of O-rings or other suitable gasket material to seal the hubs 104, 105 to the outer surface of the shaft 100. In addition, the shaft 100 may carry suitable stops 116 to determine the innermost positions of the hubs 104 and 105. The hubs 104 and 105 are joined together by a bridging member comprising a cylindrical shell 117, of steel or other suitable material, having a pair of rings 118 permanently secured to its ends and extending inwardly thereof. The inner diameter of each of the rings 118 is approximately equal to the diameter of the hub surface 109 and O-rings 119 are provided to form a seal between each hub 104 or 105 and its associated ring 118.

Attachment of the hubs 104 and 105 to the bridging member including the shell 117 and rings 118 is attained by a plurality of bolts 120 (which may be observed more clearly in Fig. 11) which extend through the flange portions 107 of the hubs 104, 105 and threadedly engage the shell 117. The bolts 120 have been illustrated in dotted lines in Fig. 10, as they are disposed between adjoining radial passages 112.

It will be observed from the structure thus far described that the hollow roller is formed so as to facilitate the circulation of the cooling medium therethrough. In order to limit the mass of the fluid within the roller, the internal space 121 of the roller is reduced in volume by the insertion of an internal cylindrical structure formed of a cylindrical member 122 and a pair of end members 123. The members 122 and 123 are permanently secured together and are attached to and carried by the shaft 100. Circulation of a coolant through the space 121 is achieved by two sets of openings 124

and 125 formed in the shaft 100 and associated baffles 126 and 127. With this arrangement the coolant may enter the right hand end of the shaft 100 and flow through openings 124, then the space 121 and the openings 125, and be discharged through the conduit 102 at the left hand end of the shaft 100.

The outer surface of the cylindrical shell 117 forming part of the roller 15 carries a cylindrical covering 128 of a material which is preferably a good heat conductor, such as brass or aluminium. The covering 128 includes a plurality of spaced, longitudinally-disposed openings or passages 129 which communicate with transverse openings 130 in the flanges 107 in order to connect the passages 129 with the radial passages 112.

Air is withdrawn from the axially disposed openings 113, previously described, by means of a pair of manifolds 131 and 132 which are identical in construction, but reversed in position so that a median plane between the two manifolds is substantially tangential to the embossing roller. This reversal in position of the manifolds 131 and 132 is necessitated by the fact that both such manifolds employ means to block vacuum passages (yet to be described) during their travel through a predetermined angular portion of roller movement. Since both manifolds 131, 132 are identical, only the manifold 131 will be described. The manifold 131 is essentially cylindrical in shape and has an internal diameter such as to permit it to be rotatably received by the bearing surface 110 of the hub 104. The manifold 131 is also provided with a side surface 132*a* which rides snugly against the bearing surface 111 of the hub 104. While the manifold 131 and the hub 104 may be made of any suitable material, it has been found that, by utilizing a material such as cast iron for the hub 104 and a material such as bronze for the manifold 131, excellent bearing is obtained with minimum loss of warmth. The manifold 131 is secured in position on the roller by a plate 133 which bears against an outer surface 134 of the manifold 131 and is secured to the hub 104 by bolts 135. If desired, the shaft 100 may include a reduced section 136, in which case the inside diameter of the attaching ring 133 would be arranged to fit such reduced section snugly and limit the innermost position of the ring.

The vacuum or air passage within the manifold 131 is in the form of an arcuate slot 137 formed in the surface 132*a* of the manifold. The diameter of the slot 137 is co-ordinated with the axially disposed openings 113 of the hub 104 so that when the manifold 131 is in position on the roller as illustrated, the passages 113 will be aligned with the arcuate manifold slot 137. A conduit 138 is threadably inserted in an opening 139 of the manifold and communicates with the arcuate slot 137.

The conduit 138 may be connected to a suitable vacuum pump or equivalent means for extracting air from the embossing roller 15.

It has previously been pointed out that it is desirable to cut off the vacuum from successive portions of the embossing roller 15 as they pass between the point of stripping the finished product from the embossing roller 15 and the point at which the film 11 is applied to the roller 15 for the embossing operation. This is accomplished by limiting the angular extent of the slot 137 in the manifold 131, as will be observed more clearly in Fig. 11. In this figure it will be observed that the slot 137 has an angular extent of slightly greater than 270° and is in communication with all but four of the axially disposed openings or vacuum ports 113. These four ports 113 are, therefore, automatically blocked or closed by the manifold 131. Since the manifolds 131, 132 are fixed relatively to the embossing roller 15, it is evident that, by properly aligning the position of the manifolds 131 and 132 relative to the position of the pressure or heating roller 23 and the take off roller 32 as shown in Fig. 1, as each of the vacuum ports 113 moves through the angular position between these two rollers 23 and 32, they will be successively blocked by the manifolds 131, 132 to prevent unnecessary loss of vacuum. It is also apparent that the angular extent of the slot 137 can be arranged in any desired manner to co-ordinate the operation of the manifolds 131, 132 with the position of the take-off and pressure rollers 32 and 23 respectively, as previously described.

The embossing roller 15, while being generally useful for the embossing of plastic sheet materials, is particularly useful for fabricating cushioning materials such as are shown and described in connection with Figs. 8 and 9 of the drawings. For this purpose, the outer surface of the roller 15 is provided with an embossing layer 140 having a plurality of discrete openings or pockets 141 formed therein. In the illustrated form, this layer 140 gives the appearance of a grating, and may be formed of any suitable material having low heat conductivity as, for instance, the silicones, tetrafluoroethylenes, heat resistant rubbers, epoxy resins, and low heat conductive metals, such as alloys of tin and bismuth. While the layer 140 may be secured to the roller 15 in any desired manner, it is preferably fabricated in the form of a cylinder and assembled into the roller 15 prior to the attachment of one or both of the hubs 104 and 105 so as to be held in position by such hubs. Vacuum is applied to the openings

or pockets 141 by serrating the surface of the cylindrical covering 128, as indicated at 142 in Figs. 12 and 13, and providing spaced vacuum ports 143 connecting the serrated surface with the longitudinally disposed passages 129, as may be observed in Figs. 12 and 13. Since the embossing layer 140 is carried on top of the serrated surface 142, air can readily flow beneath the embossing layer 140 and thus the necessity of having an individual vacuum port 143 communicating with each of the individual openings or pockets 141 is avoided.

Fig. 14 illustrates the flow of air beneath the embossing layer 140, by reason of the utilization of the serrated surface 142, and it is evident that alternative structures may be employed for this purpose as, for instance, a layer of woven material such as a metal screen 144 or the like, as shown in Fig. 17.

In certain cases it may be desirable to fabricate the embossing layer 140 of a material having increased heat conductivity in order to effect more rapid cooling of the embossed plastic film. In such an instance it may be desirable to coat the surface of the embossing layer 140 with a material such as an epoxy resin and silicone resin, or the like, as indicated at 145 in Fig. 12 in order to isolate the unembossed portions of the film from contact with the outer surface 146 of the embossed layer 140. The heat-insulating layer 145 may be either rigid or resilient as may be desired. In this way increased cooling of the formed portions of the film would be obtained, while the unembossed portions, which are to be fused onto the sealing layer 13 would remain at a reasonably high temperature to ensure complete fusion. If rapid cooling is not required, the embossing layer 140 may be fabricated of a material having good heat insulating characteristics, in which instance a surface layer of insulating material would not be required. This structure is illustrated in Fig. 18.

A further modification of the embossing layer 140 is illustrated in Figs. 15 and 16, wherein both the serrated surface 142 and the screen 144 are eliminated. In this case, the embossing layer is provided, as in the previous embodiments of the invention, with a plurality of embossing openings or pockets 141 separated by defining walls 148. Each of the walls 148 in this embodiment, however, is provided with a channel 149 formed in the inner surface in order to permit air to flow freely from pocket to pocket, and thus enable the spaced vacuum ports 143 to evacuate all of the pockets 141 to effect the embossing operation.

In the form of embossing roller shown in Figs. 15 and 16, the embossing layer is coated with an insulating resin 150, which corresponds to the heat-insulating layer 145 shown in Fig. 12, and further includes an outer layer 151.

The outer layer 151 preferably constitutes a thin section of a heat conductive material which can be heated and which would retain the heat for a reasonable period after the completion of the laminating operation, as previously described. The utilization of the conductive outer layer 151 enables the unformed portions 11^1 (see Fig. 8) of the embossed film 11 to be maintained close to the fusing temperature while selectively cooling the embossed product. The outer layer 151, being of a conductive material, may be readily heated by any suitable source of radiant energy, and particularly high frequency energy that would have a more pronounced effect in selectively heating the outer layer 151.

The embossing roller 15 herein described has a significant advantage in that it affords individual control of the vacuum and cooling medium, which greatly simplifies the operation of the equipment and affords a more versatile piece of apparatus. Furthermore, the unique arrangement and co-ordination of the elements enables the embossing roller 15 to be formed in individual sections which can readily be taken apart for cleaning and/or for modifying the embossing surface. Thus, if a change in pattern is required, it is merely necessary to replace the embossing layer 140 with another embossing layer having modified openings or pockets to effect the desired result.

While various embodiments of the embossing roller have been illustrated and described, it is of course evident that changes can be made in the construction of such roller while retaining the numerous advantages such as independent control of the vacuum and cooling mediums, selective control of the vacuum applied to the vacuum conduits, and ready exchangeability of the embossing layer.

It will be understood also that only certain forms of the invention have been illustrated and described herein and that changes, modifications and alterations may be made without departing from the scope of the invention as defined by the appended claims.

WHAT WE CLAIM IS:—

1. Apparatus for embossing and laminating synthetic plastic films or sheet materials comprising an embossing roller including a cylindrical shell mounted for rotation and containing a chamber through which cooling fluid may be circulated, vacuum passages being provided in communication with surface openings or pockets of the roller to permit vacuum to be applied to such openings or pockets, said passages

being connected to a vacuum conduit, means for heating a first synthetic plastic film or sheet to embossing temperature and feeding it continuously to the embossing roller, means for heating a second synthetic plastic film sheet to a fusing temperature and feeding it onto the embossing roller in overlying relationship to the first film or layer, and a take off roller for receiving the combined films as they pass off the embossing roller after having cooled therein.

2. Apparatus as claimed in Claim 1 wherein the shell has a plurality of vacuum passages therein, and is surrounded by an embossing layer wherein the surface openings or pockets which communicate with the vacuum passages, are provided.

3. Apparatus as claimed in Claim 2 wherein the vacuum passages are disposed in spaced parallel relationship one to the other and to the axis of rotation of the roller and further including means whereby the vacuum is applied to the vacuum passages as they move through a predetermined angle of rotation of the roller and the vacuum is interrupted to the passages as they move through the remaining angle of rotation of the roller.

4. Apparatus as claimed in Claim 3 wherein the roller comprises a pair of hubs carried by a hollow shaft and disposed one at each end of the shell, each hub, having a plurality of passages each communicating with one of the vacuum passages in the shell and terminating at the outer face of the respective hub, the said means whereby the vacuum is applied comprising for each hub, a manifold carried by and rotatable relative to its respective hub and having an arcuate vacuum slot which registers only with those vacuum passages within the said predetermined angle.

5. Apparatus as claimed in Claim 2, 3 or 4 wherein the embossing layer is removably secured to the shell.

6. Apparatus as claimed in any preceding claim wherein the outer salient portions surrounding the openings or pockets of the roller are provided with a layer of heat-insulating material.

7. Apparatus as claimed in Claim 6 wherein the layer of heat-insulating material is resilient.

8. Apparatus as claimed in Claim 6 or 7 wherein a layer of heat-conductive material is provided over the layer of heat-insulating material.

9. Apparatus as claimed in any preceding claim wherein means are provided for spraying a coolant onto the films to set them, prior to passing off the embossing roller.

10. Apparatus as claimed in Claim 9 wherein the coolant is a liquid and the apparatus further includes gas pressure means for doctoring the liquid prior to passage of the combined films off the embossing roller.

11. Apparatus as claimed in any preceding claim wherein the means for heating the first synthetic plastic film or sheet and feeding it to the embossing roller comprises a pair of gas manifolds positioned in overlying relationship, the confronting faces of such manifolds each having a plurality of orifices therein, means for feeding the first film or sheet between the manifolds and onto the embossing roller, and means for supplying heated gas under pressure to the manifolds so that it is discharged onto the film so as both to heat the film and support it physically.

12. Apparatus as claimed in Claim 11 wherein the median plane between the manifolds is substantially tangential to the embossing roller.

13. Apparatus as claimed in any of the preceding claims wherein a first pressure roller is provided for pressing the first film or sheet onto the embossing roller so as to take up the conformation of the latter prior to the feeding of the second film or sheet onto the roller.

14. Apparatus as claimed in Claim 13 wherein the pressure roller is heated.

15. Apparatus as claimed in any of the preceding claims wherein a movable endless belt is provided in engagement with at least part of the periphery of the embossing roller and serves to hold the first and second films or sheets tightly together during setting thereof.

16. Apparatus as claimed in Claim 15 wherein means is provided for cooling the endless belt.

17. Apparatus as claimed in Claim 16 wherein the means for cooling the endless belt comprises a cooled pressure roller.

18. Apparatus as claimed in any of the preceding claims further including means for heating the surface of the embossing roller in advance of the application of the first synthetic plastic film or sheet.

19. Apparatus as claimed in any of the preceding claims further including means for heating a third synthetic plastic film or sheet, and means for feeding such third film or sheet in overlying pressure engagement with the outer faces of the embossed portions resulting from entry of parts of the first film into the surface openings or pockets of the embossing roller, so as to seal the third film onto such embossed portions, and means for cooling the third film.

20. Apparatus as claimed in Claim 19 wherein the means for cooling the third film

comprises a heat conductive belt and means for cooling the same.

21. Apparatus for embossing and laminating plastic films or sheet materials substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

W. P. THOMPSON & CO.,
12 Church Street, Liverpool 1,
Chartered Patent Agents.

Reference has been directed in pursuance of Section 9, Subsection (1) of the Patents Act, 1949, to Patent No. 725,436.

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3 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 1

Fig.1.

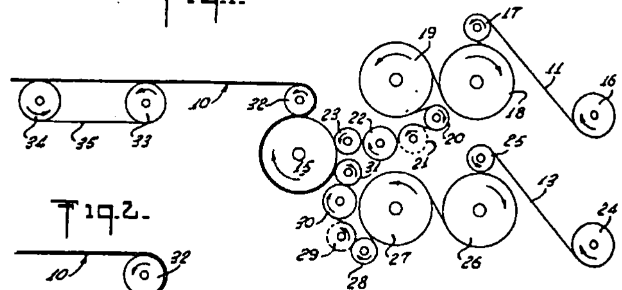
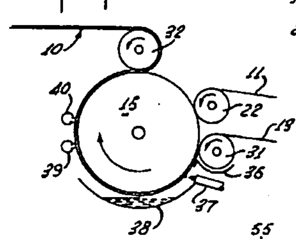


Fig.2.



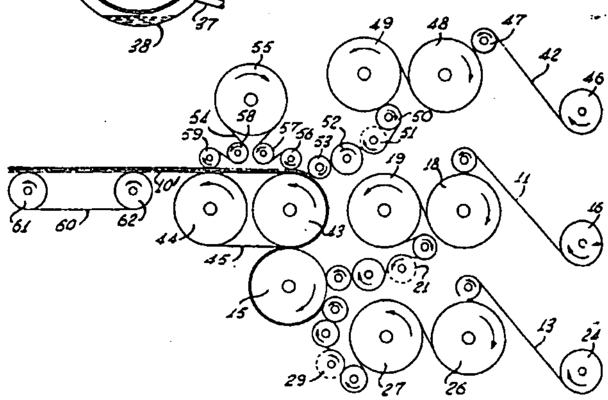


Fig.3.

Fig.4.

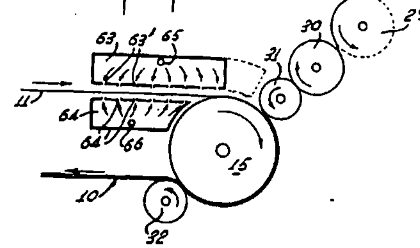


Fig.5.

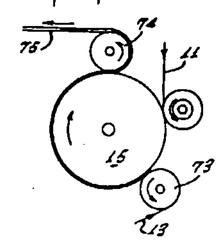
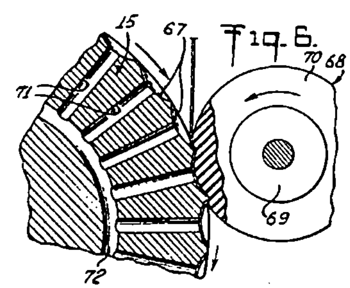


Fig.6.



942214 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

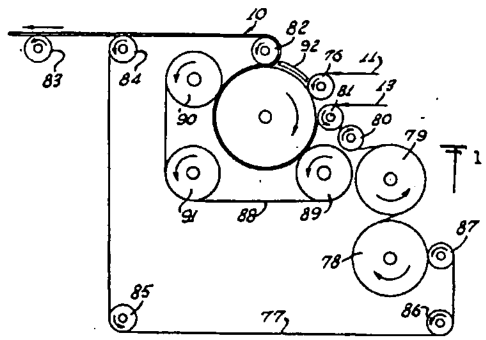


Fig. 7.

Fig. 8.

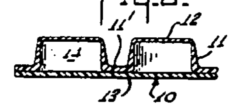


Fig. 9.

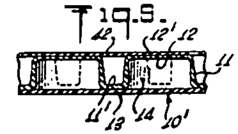


Fig. 10.

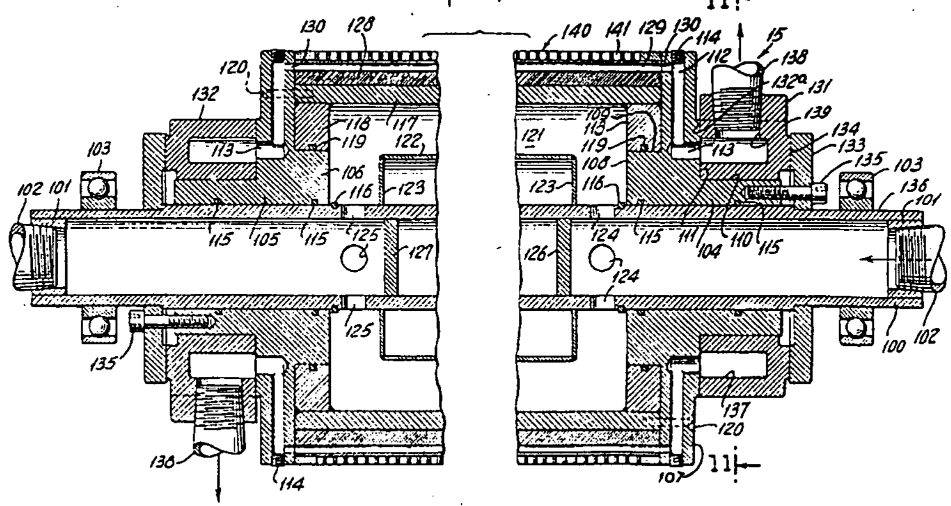


Fig.11.

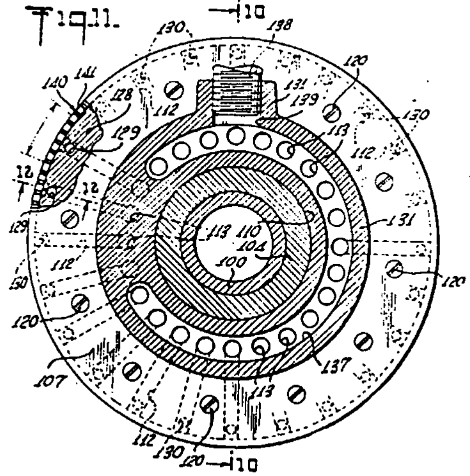


Fig.12.

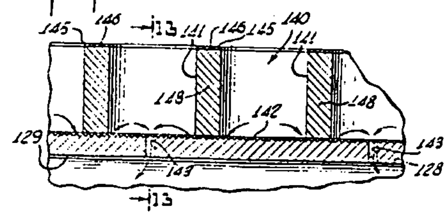


Fig.13.

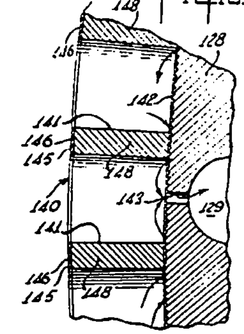


Fig.14.

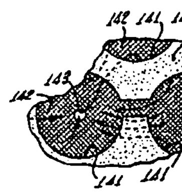
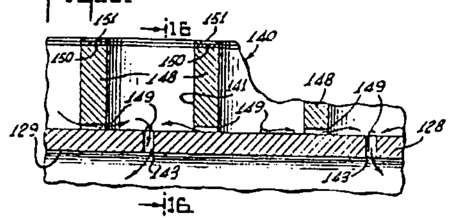


Fig.15.



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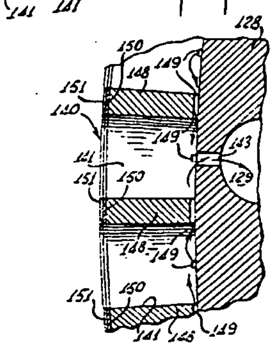

Fig.17.

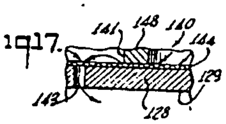

Fig.18.